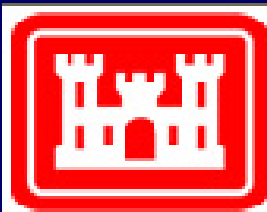


# FLOOD INUNDATION MAPPING SCIENCE



Gardner Bent, U.S. Geological Survey, New England Water Science Center



FEMA





# What is Flood Inundation Mapping?

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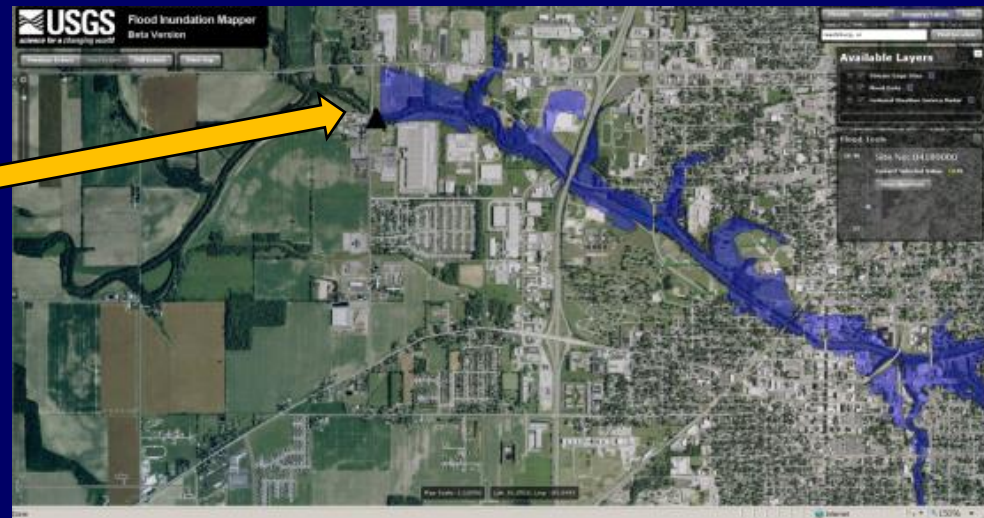
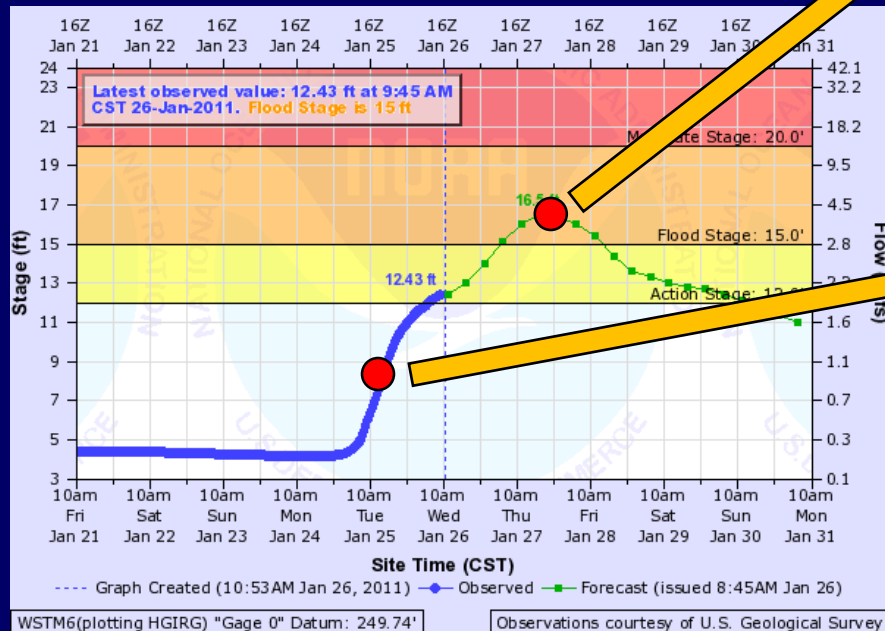
***Flood Inundation Mapping (FIM)*** is a real-time, operational tool that visually relates USGS streamgauge data and NWS forecasts to flood risk for the primary purpose of ***public safety***, but also has significant benefits of:

- Understanding changing natural processes that produce hazards
- Development of hazard mitigation strategies and technologies
- Effectively reduce vulnerability and repetition of loss to infrastructure
- Promotion of risk-wise behavior

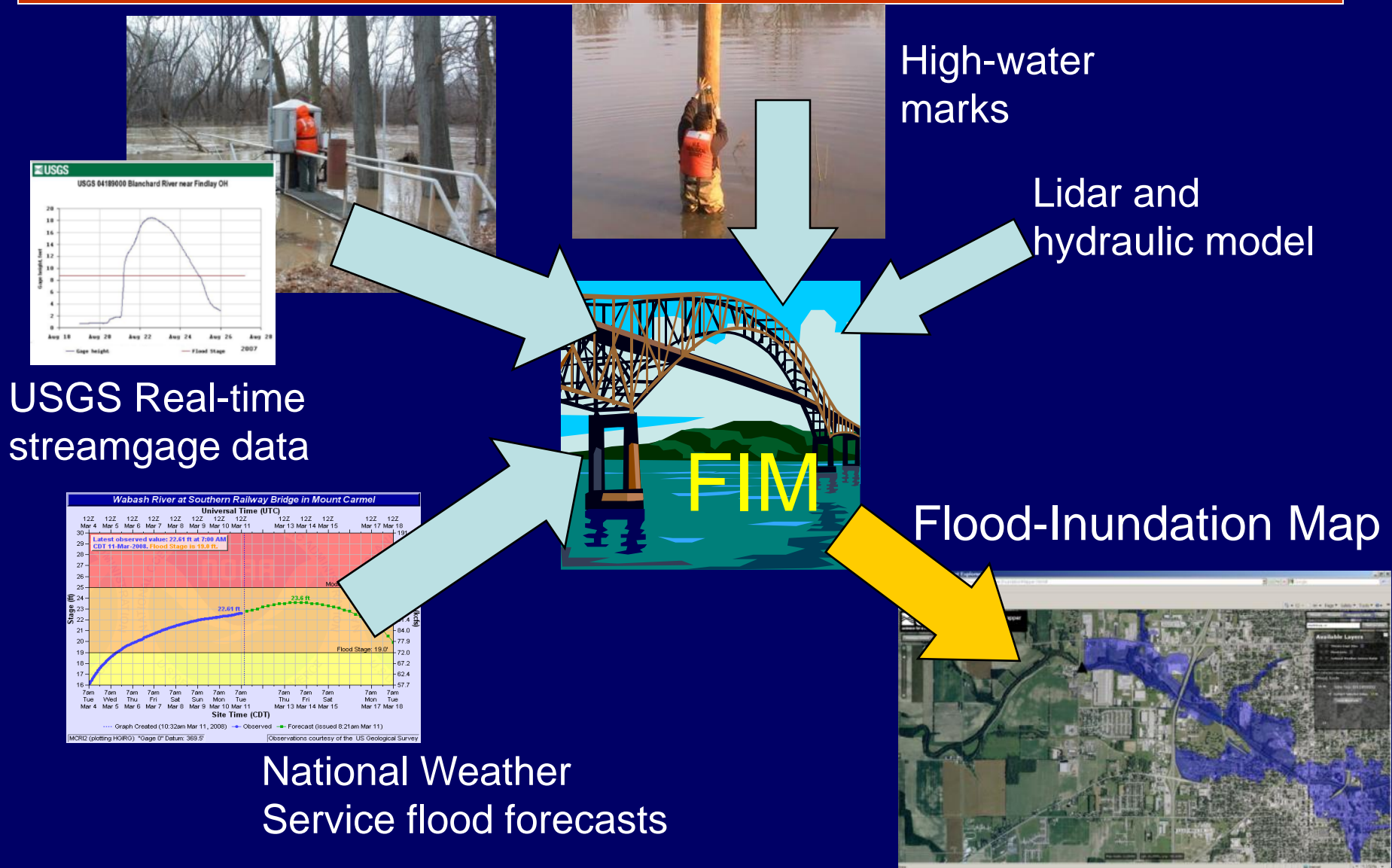


# Flood Inundation Maps (FIM)

- Translate a hydrograph into operational maps that communicate risk and consequences



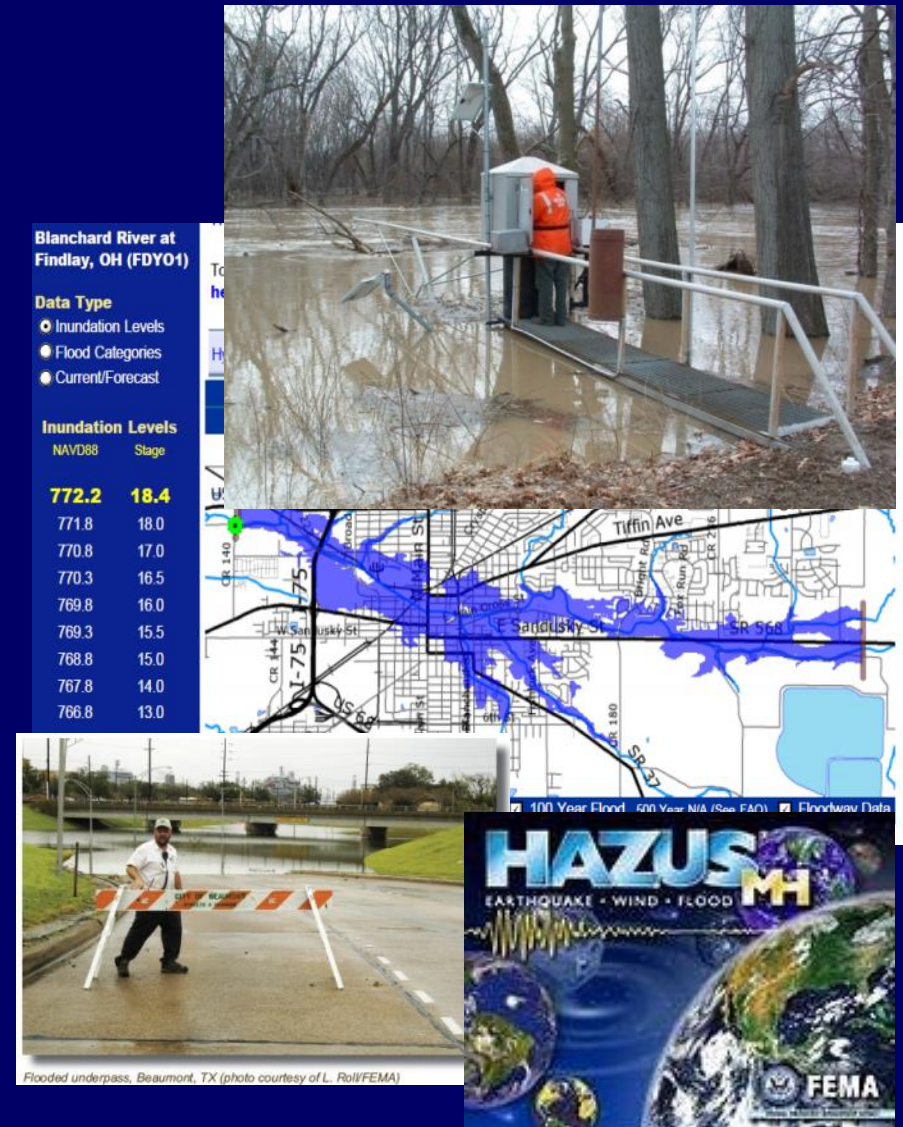
# Flood Information – from a point on the landscape to geospatial products





# Inundation Mapping becomes a tool for flood...

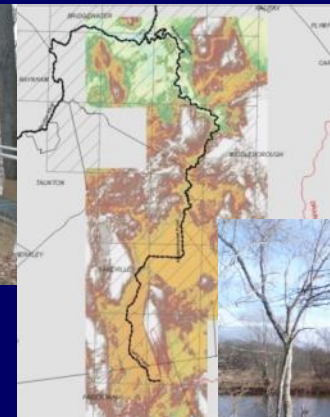
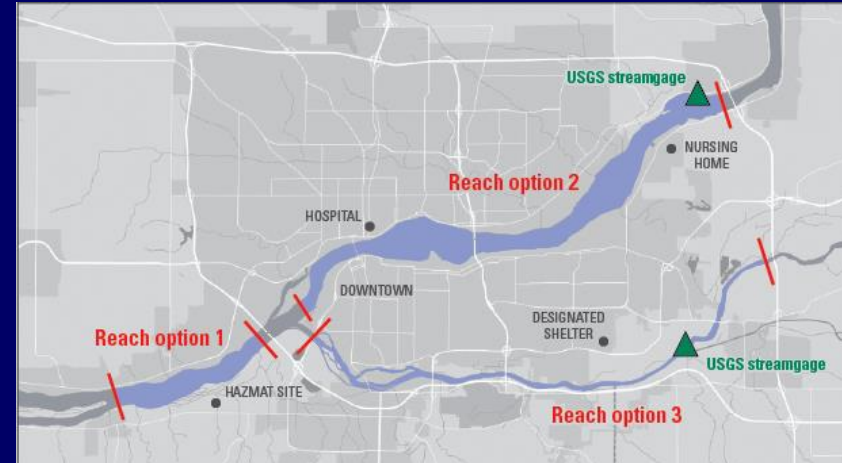
- Preparedness
  - “What-if” scenarios
- Response
  - Tied to streamgage and forecast data
- Recovery
  - Damage assessment
- Mitigation and planning
  - Flood risk analyses
- Environmental and ecological assessments



# Creation of Flood Inundation Maps

## Chose Reach and Data needed

- Critical infrastructure, populations, escape routes needed
- Streamgauge and flood forecast
  - Stable high-end rating, peakflow analyses
  - Can also do with stage-only
- Elevation data availability
  - Topography - lidar
- Recent survey
  - Hydraulic structures and x-sections
- High-water marks
  - Recent or historic flood



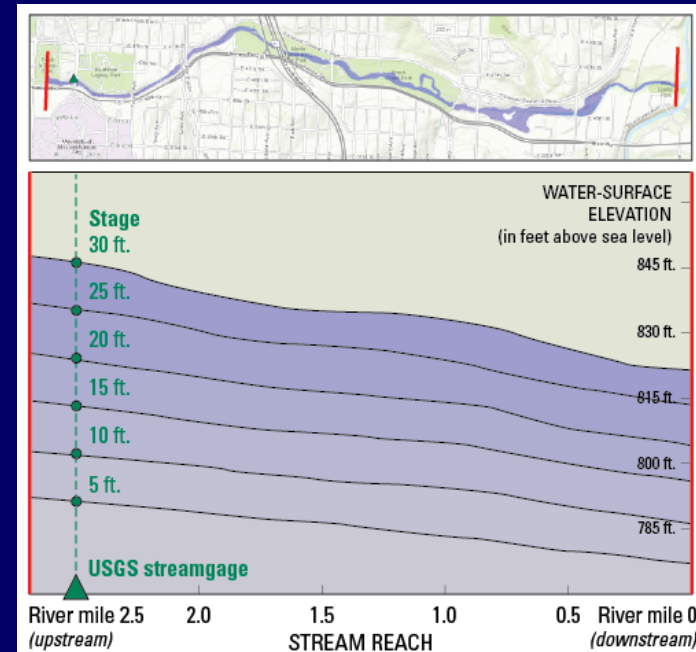
# Creation of Flood Inundation Maps

## Calibrated Hydraulic model

- FEMA approved hydraulic model (typically using HEC-RAS, 1-D, steady state)

## Stage increments

- 1 or 2 ft increments from bankfull to 0.2 percent chance flood
- Associated with peakflow annual exceedance probabilities (AEPs) such as 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent (2-, 10-, ... 500-year flood)



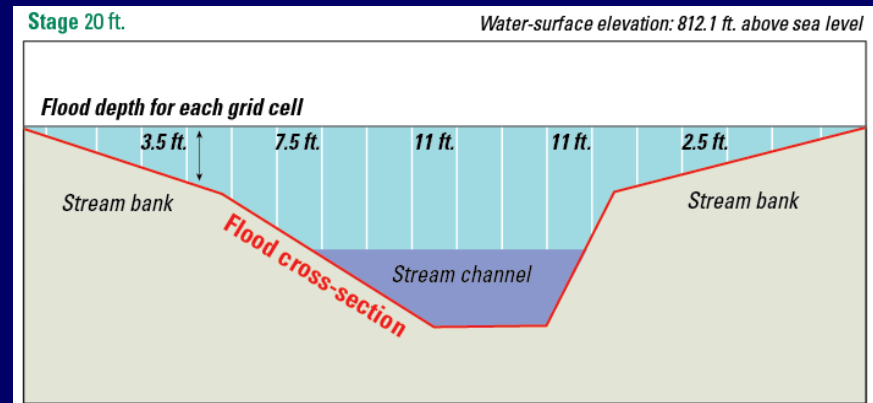
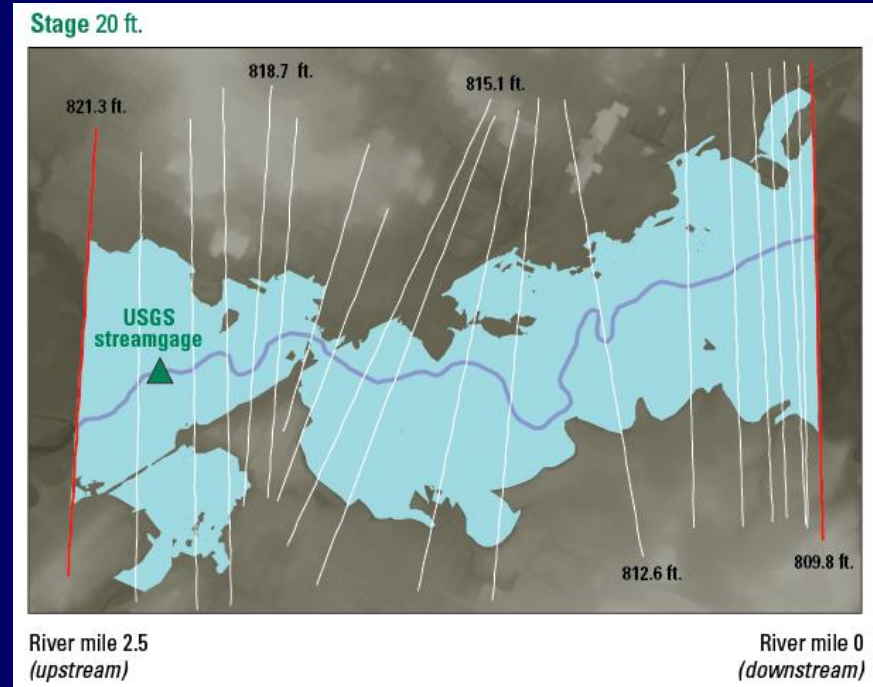
# Creation of Flood Inundation Maps

## Delineation of inundation

- Data for incremental stages are combine with Lidar – based DEM
- Spatial grid of where flooding occurs based on stages

## Inundation depth

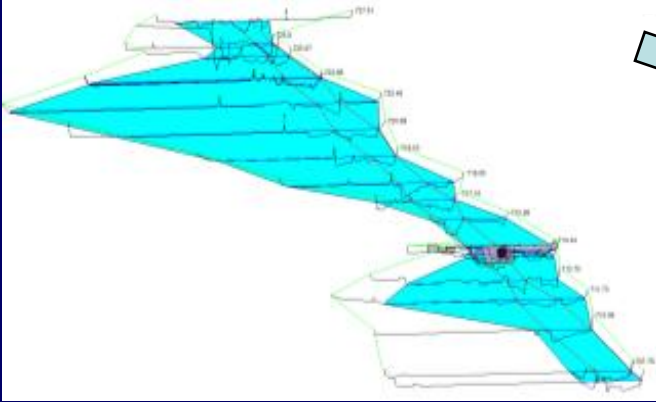
- Depth grids are determined for stage increments



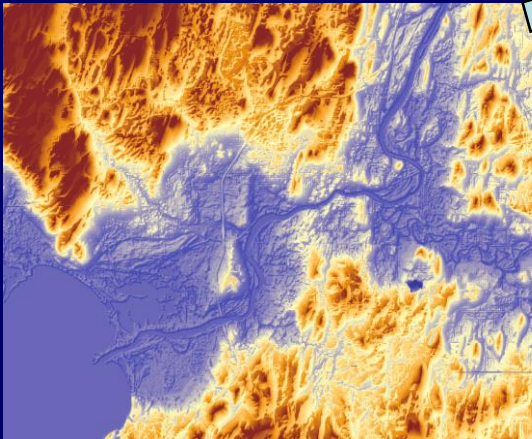


# Creation of Flood Inundation Maps

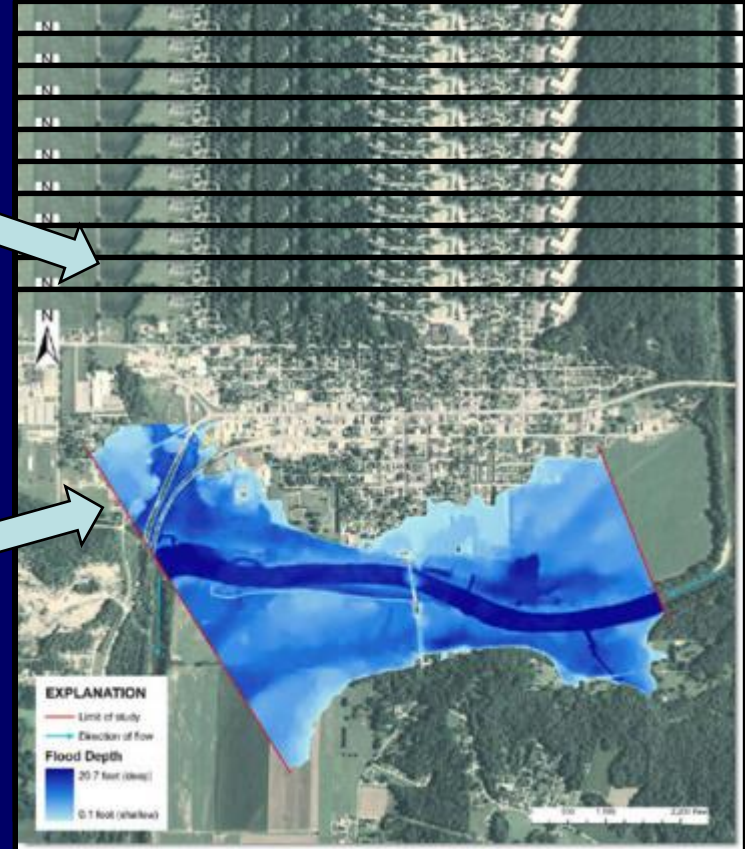
## Hydraulic Modeling



## Geospatial Processing

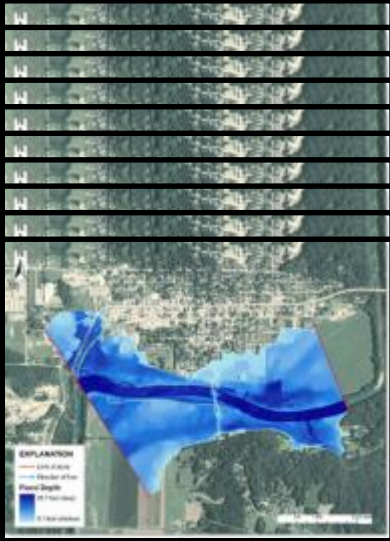


Digital Elevation Model

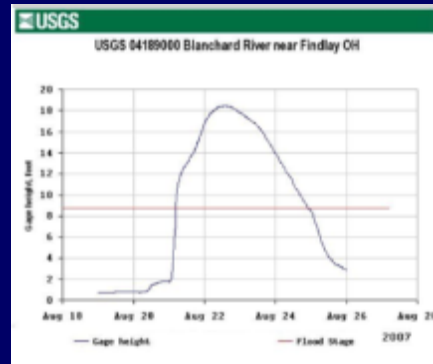
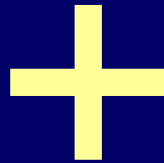


Series of sequential maps showing probable areas of flooding

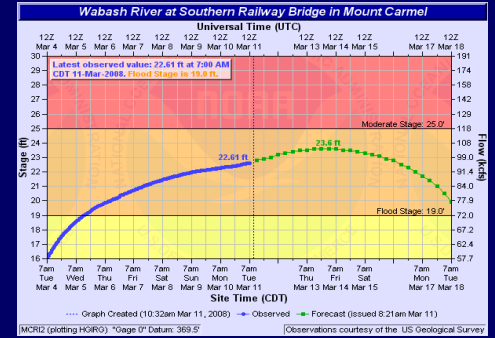
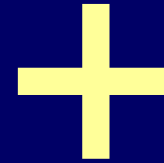
# FIM Mapper – more than just maps



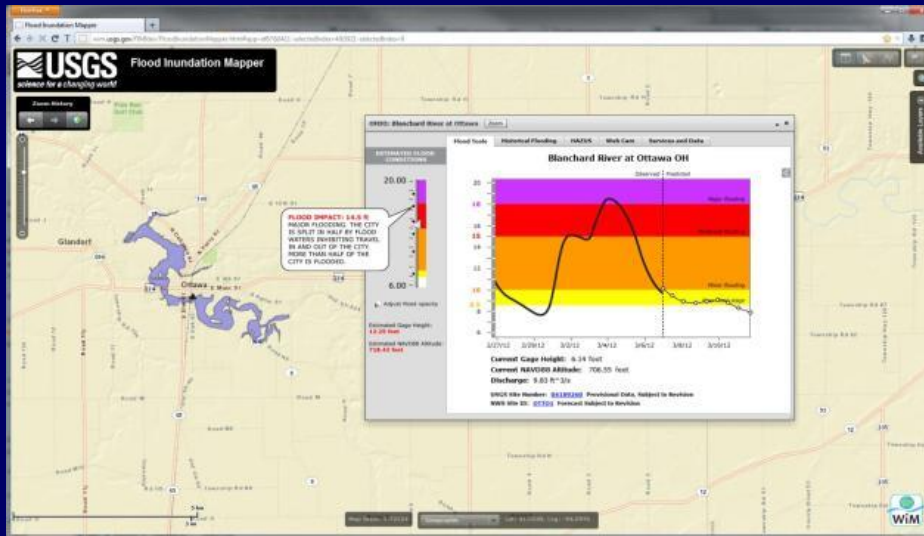
# Flood Library



# USGS Real-time streamgauge



# NWS Flood Forecast



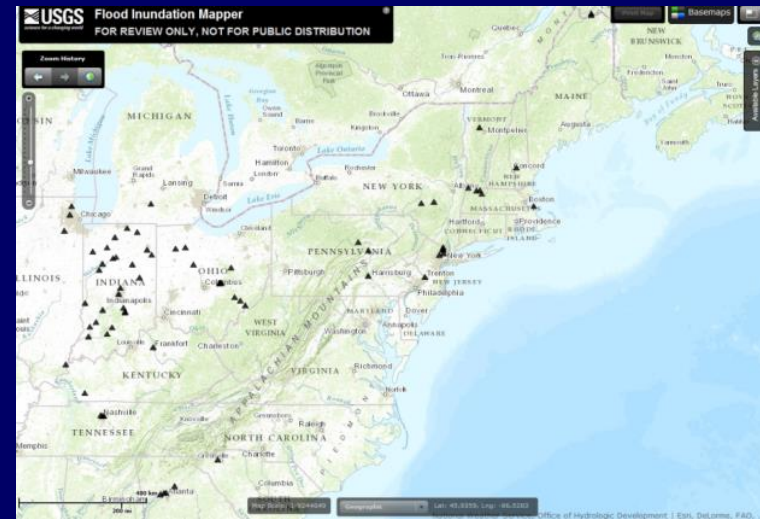
<http://wim.usgs.gov/FIMI/>



# FIMs Studies in New England

## Published and on USGS FIM mapper

- Suncook River at North Chichester, NH
- Winooski River above Crossett Brook at Waterbury, VT
- Hoosic River near Williamstown, MA
- Deerfield River at Charlemont, MA
- Deerfield River near West Deerfield, MA
- North River at Shattuckville, MA
- St. John's River below Fish River near Fort Kent, ME
- Fish River near Fort Kent, ME



# FIMs Studies in New England

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## On USGS FIM review mapper

- Green River near Colrain, MA

## USGS FIM studies on going

- Lake Champlain – Vermont and New York

## USGS FIM studies to start soon

- Pawtuxet River at Cranston, RI

## *Proposed USGS FIM studies*

- *Deerfield River at Buckland/Shelburne Falls, MA*
- *Green River at Greenfield, MA*
- *Deerfield River at Greenfield/Deerfield, MA*



# FEMA – NH Riverine Studies

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## Watershed's with river reaches studied in detail

- Discovery meetings for Merrimack Watershed (MA and NH) in July 2015
  - Provisional list of NH sites – not final version
    - Spicket River (streamgage)
    - Suncook River
    - Beaver Brook (streamgage)
    - Dalton Brook
    - Hasells Brook
- Discovery meetings for Nashua Watershed – tributary to Merrimack River *in late April - early May 2016*

# FEMA – NH Riverine Studies

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## FEMA RiskMAP Studies

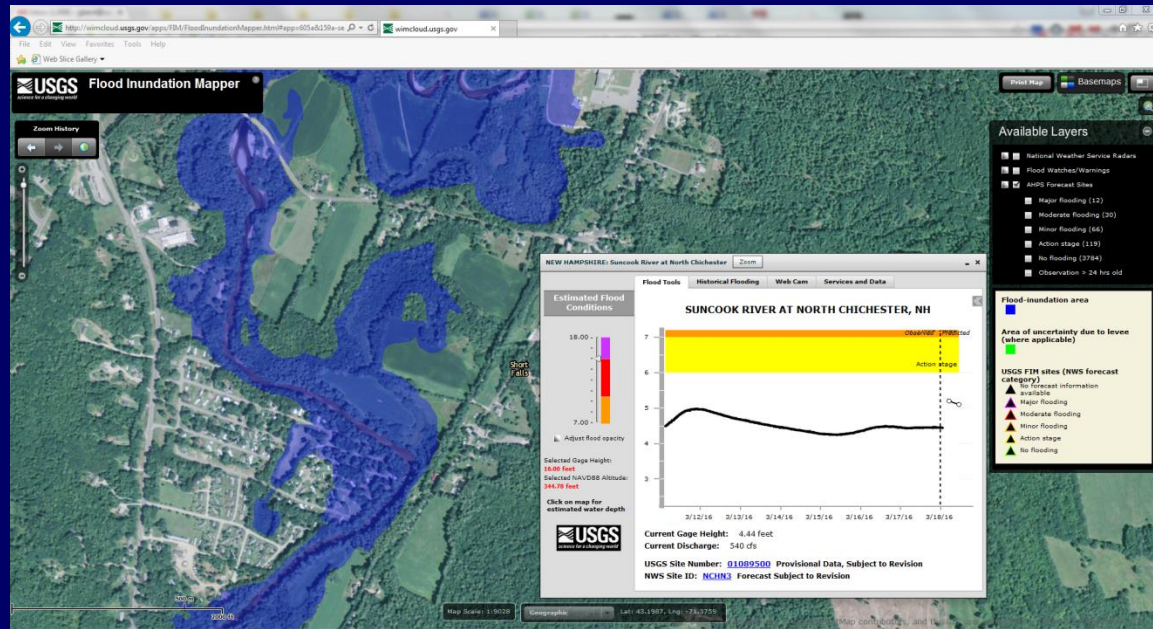
### Merrimack and Nashua Watersheds

- Selected river reaches will be studied in detail using:
  - Lidar
  - HWMs for model calibration
  - Surveyed hydraulic structures (bridges and dams)
  - Updated flood flows
  - New hydraulic models
- *From here FIMs could be created for river reaches studied in detail and with a USGS streamgauge*

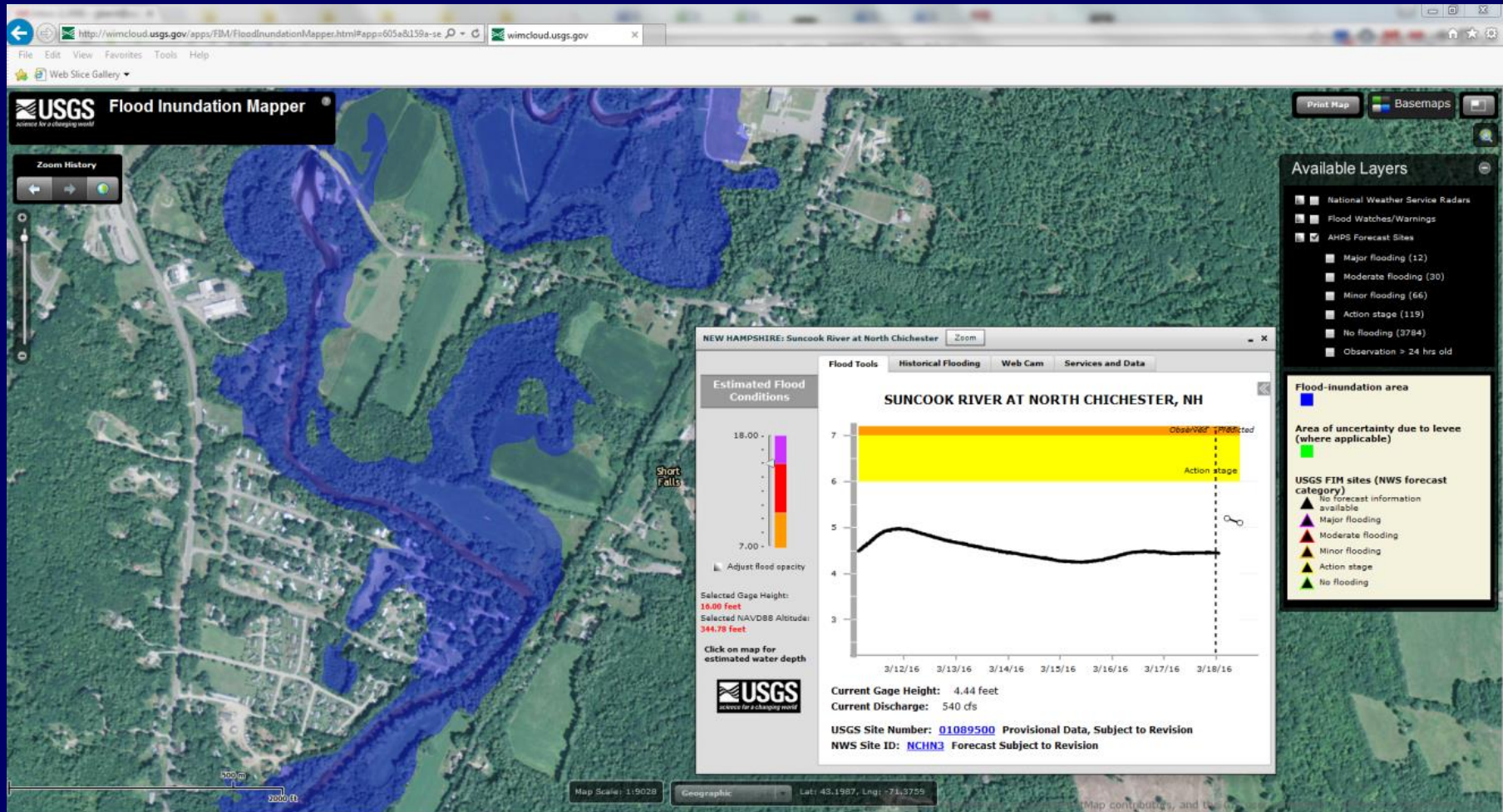


# Possible FIMs in New Hampshire

- Any river reach with a USGS streamgauge (stage-only also)
- Possible river reaches:
  - Ashuelot River
  - Connecticut River
  - Contoocook River
  - Merrimack River
  - Pemigewasset River
  - Pitcataquog River
  - Saco River
  - Souhegan River
  - Spicket River



# FIM Web Mapping Application



<http://wimcloud.usgs.gov/apps/FIM/FloodInundationMapper.html>

# FIM Benefits



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- Helps with preparedness, response, recovery, and mitigation and planning
- Interactive tools give users a better understanding of flood risk areas
- Data can be shared by many users simultaneously to make decisions to reduce flood losses (before, during, and after)
- Help assess cost and damages of floods (*HAZUS*)
- USGS report documenting flood flows, hydraulic model, calibration, lidar, mapping, and map libraries
- Potentially helps communities with their NFIP community rating, and consequently lower flood insurance premiums



# Questions

[http://water.usgs.gov/osw/flood\\_inundation/](http://water.usgs.gov/osw/flood_inundation/)



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**USGS Flood Inundation Mapping Science**

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## Flood Inundation Mapping (FIM) Program

Floods are the leading cause of natural-disaster losses in the United States. More than 75 percent of declared Federal disasters are related to floods, and annual flood losses average almost \$8 billion with over 90 fatalities per year. Although the amount of fatalities has declined due to improved early warning systems, economic losses have continued to rise with increased urbanization in flood-hazard areas. The **USGS Flood Inundation Mapping (FIM) Program** helps communities protect lives and property by providing tools and information to help them understand their local flood risks and make cost-effective mitigation decisions.

The **USGS Flood Inundation Mapping Program** has two main functions:

**1) Partner with local communities to assist with the development and validation of flood inundation map libraries.**

A flood inundation map library is a set of maps that shows where flooding may occur over a range of water levels in the community's local stream or river. The USGS works with communities to identify an appropriate stream section, gather the necessary data to model where flooding will likely occur, and verify that the maps produced are scientifically sound. To learn more about the scientific process of developing a map library, visit the [FIM Science section](#).

Inundation maps can be used for:

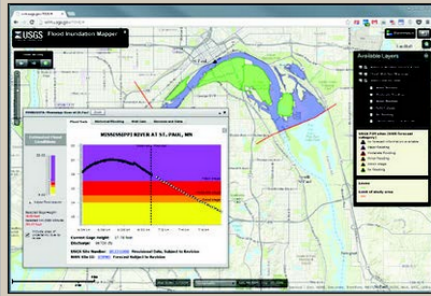
- *Preparedness* - "What-if" scenarios
- *Timely Response* - tied to real-time gage and forecast information
- *Recovery* - damage assessment
- *Mitigation and Planning* - flood risk analyses
- *Environmental and Ecological Assessments* - wetlands identification, hazardous spill cleanup

To help communities create a flood inundation map library, the USGS created the [FIM Toolbox](#), which contains development resources and contact information.

**2) Provide online access to flood inundation maps along with real-time streamflow data, flood forecasts, and potential loss estimates.**

Once a community's map library is complete, it is uploaded to the [USGS FIM Mapper](#), an online public

### Flood Inundation Mapper



Visit the [Flood Inundation Mapper](#) to explore flood inundation maps, streamflow conditions, flood forecasts, potential loss estimates, and more...

### FIM Toolbox

Visit the [FIM Toolbox](#) to learn more about developing a flood inundation map library for your community.

### Download

Download the [FIM Information Sheet](#) to share information about the flood libraries and the FIM Program with others.

# Example of Flood Inundation Mapping

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Stage = 14.00 ft





# Example of Flood Inundation Mapping

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Stage = 16.00 ft





# Example of Flood Inundation Mapping

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Stage = 18.00 ft





# Example of Flood Inundation Mapping

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Stage = 20.00 ft





# Example of Flood Inundation Mapping

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Stage = 22.00 ft

